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How Industry 4.0 concepts are applied in the Portuguese clothing industry: some evidences.

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Abstract. Industry 4.0 is the current trend of automation and data exchange in manufacturing technologies, including textile and clothing industry. The concept of Industry 4.0 is based on the integration of information and communication technologies, industrial technology and is mainly dependent on building a Cyber-Physical System (CPS) to prepare a digital and intelligent factory, to become more digital, customized and (why not?) also green. The purpose of Industry 4.0 is to build a highly flexible production model of personalized and digital products and services, with real-time interactions between people, products and devices during the production process. This paper will show how a Portuguese clothing company (GUIMA) is preparing their processes, skills and resources to be in the Industry 4.0. The research team is following the industrial process for four months, starting from the reception and quality control of raw materials and accessories, until the orders expedition to different customers. Some results already obtained shows how the digitalization is yet in a preliminary stage in the clothing industry and is necessary to prepare the entire resources from the clothing company to achieve the horizontal and vertical integration in the manufacturing I4.0.

1. Introduction

The Portuguese clothing industry is a traditional, important and mature industrial sector. The textile and clothing industry (ITV) include 6,000 societies and 5,600 individual companies, employing a total of about 130,000 direct workers, producing 6.4 billion Euros and generating € 6.8 billion in turnover, in which € 4.8 billion are due to export activities [1].

The Fourth Industrial Revolution is taking place in this new millennium, also called the Digital Revolution, through technologies such as the Internet of Thing (IoT); Artificial Intelligence (AI); Virtual Reality (VR); Social, Mobile, Analytics and Cloud (SMAC) interaction, etc., to transform the real world into a digital world. In 2013, the new keyword "Industry 4.0" starts to emerge from a German government report that mentions this phrase in terms of high-tech strategy. Industry 4.0 is the current trend of automation and data exchange in manufacturing technologies that based on the integration of information and communication technologies, industrial technology and is mainly dependent on building a Cyber-Physical System (CPS) to prepare a digital and intelligent factory [2]. The purpose of Industry 4.0 is to build a highly flexible production model of personalized and digital products and services, with real-time interactions between people, products and devices during the production process [3].

Industry 4.0 is the intelligent interaction between machine-to-machine and human-to-machine through sensors, RFID, barcodes and tags, all of it used to collect data in the real production process. Industry 4.0 is driven by digitization and integration of vertical and horizontal production chains and end-to-end value chains. Vertical and horizontal integration allows the company to share real-time data, product specificity of each location, real-time



productivity of workers, units produced, and data are quickly accessed and shared. The use of sensors and RFID makes the access and retrieval process fast and accurate. Finally, end-to-end use to the product development process [4]. Through IoT and CPS, the information is shared, monitored, made decentralized and self-optimizing. Real-time communication Machine-to-Machine (M2M) and Machine-to-Person (M2P) are connected in standard protocols [5],[6].

Industry 4.0 facilitates the creation of "smart factories" or "digital factories." With IoT, these virtual physics systems interact with each other and with people in real time, and through IoS the user will be involved in the value chain using these services. Industrial control systems will become far more complex and widely distributed, enabling flexible, fine-grained process control. Smart and connected embedded devices will be everywhere. Sensors and radio frequency identification technologies (RFID) will be assisted in every stage during the manufacturing process, providing the raw data as well as the feedback that is required by control systems. Industry 4.0 will be the virtualization and modularization of manufacturing and supply chain processes, achieving flexibility and personalization based on CPS and IoT along with ERP, MES, PLM, SCM [7].

According the last data of Digital Economy and Society Index 2017 [8], the Portuguese companies have integrated the Digital Technology in their processes: 44% of them are using Electronic Information Sharing (EIS) and 8% RFID.

2. Methodology Research

The research method used in this paper is the case study and documental analysis [9], from that using evaluated, estimated, tested standards and to predict trends of evolution in the future for throughout Bayesian process [10]. This is a method which can give some indications and allow further elaboration and hypothesis creation for companies that have similar conditions [11],[12].

The way to be performed this method is gathering data of the Portuguese clothing company GUIMA which is preparing their processes, new technologies, resources and professional skills to be in the Industry 4.0 revolution. This enterprise is a clothing company firm belongs to a bigger textile group (SOMELOS SGPS), with vertical production (spinning, warping, sizing, weaving, dyeing and finishing) and own brand in their fabrics. SOMELOS Fabrics is the main supplier of raw materials of GUIMA (fabrics to produce the GUIMA's shirts).

The research team followed the industrial process of this company for four months, with targets and check points to be followed and analysed such as the reception of raw materials and other items for the shirts, quality control of raw materials and accessories, production processes (quantities, efficiencies and lean times) and closes with the orders expedition to different customers.

3. Case study: GUIMA

The clothing production process starts with yarn, fabric, accessories and apparel manufacturing. Fashion accessories industry is known as one of the parts of the global fashion industry, which is the place that logistic providers are using many supply chain management (SCM) and used in retail stores.

In 2016, GUIMA was beginning to deploy a developed solution called FluxoConf. The aim of this solution is to support the process of storage, production, monitoring of production, efficiency analysis in order to make a controlling decision timely. This solution is focused in some respects as:

- Orders are ready to go into production;
- Collect average real time in production (product unit/ time unit);
- Evaluate individual average levels of productivity;
- Positioning of parts in production;
- Production efficiency of company.

The case study research method is applied in context of GUIMA that will be categorized into three steps (figure 1): Preproduction processes, Production processes and Postproduction

processes (Classification in basic steps in the apparel production [13][14]), they are going to be described for each of steps follow by:

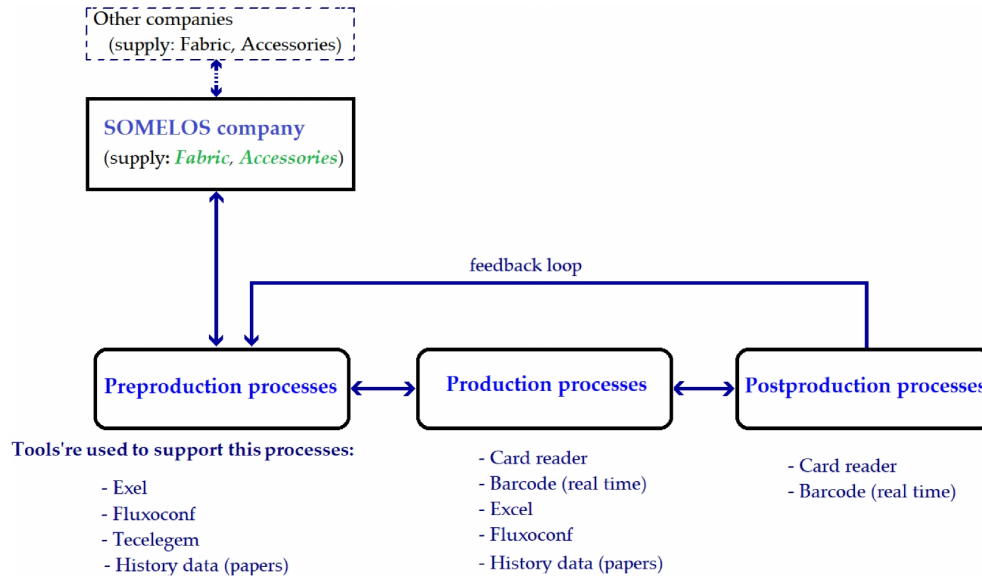


Figure 1. GUIMA processes system

3.1. Preproduction processes

The GUIMA uses Tecelagem software to create the production planning program.

-First, they are sent to the involved sections to find out the price of the items; initial estimate consumption of fabrics, trims, threads and materials for each unit of product as well as for all products in the orders respectively.

-Second, they will analyze the real productive capacity available (i.e. these capacities are depended on aspects of FluxoConf solution) to give a confidence interval for established order deadline and to reply to customers about delivery time.

-Third, using Tecelagem software to buy fabrics from Somelos in the shortest time. This software is supplied by Somelos Company.

Moreover, this department is also responsible for preparing all information for GUIMA's production such as patterns, cutting plans, technical assembly and the consumption of materials. They use CAD/CAM provided by the Gerber software. However, on the same time, the consumption of materials still uses an excel template and has not been integrated into the Fluxoconf software. Assembly steps are created without the help of the software and then go to the production department to join specific work steps.

The next step is designing pattern and preparation of the cutting plan (marker). GUIMA works with a CAD/CAM system provided by Gerber software. Patterns are created and then they are used to prepare the cutting plan. Patterns are scaled in the various sizes according the commercial order from clients in obtain the best fabric consumption. Cutting plan must be carefully considered because the most significant part of the cost of a clothing item is imputed to the material, and so any reduction in consumption leads to an increase in expected profit. The plans are made according to the orders of the various models and customers.

Fluxoconf is used in the preparation of the work phases and the documents have still been given to the production department by hand to ensure that the production will be done on time.

3.2. Production processes

First, this department receives, checks and counts the materials, trims, threads and accessories from preproduction processes, to ensure they are enough to complete the order before to go to

the production process. In this period, they create and describe very specific operations step by step as well as time to imply them (the document will define the sum of the duration of operations of each part and the cost to be assigned to the product/minute), timekeeping management and always coordinates with other departments to handle any arising problems (if any) in the production process. Warehouse management, productivity and improvement of sewing performance are also based on software data to monitor.

The fabrics and accessories delivered to GUIMA are stored in the warehouse on shelves for future cutting and using operation. The cutting part is only performed after this department was received all the information related to the needs of fabric and accessories, the quantities to be produced and the deadline of delivery to the customer, and then material requirements are forwarded to their warehouses.

The storage process was also restructured by a program developed by Fluxoconf that allows assigning locations to the shelves by “street”, “letter” and “number”. This program allows in the entrance of fabric to be assigned a location that identifies its position in the warehouse. This process allows extremely fast location to meet the needs for a order. Another advantage is that it is possible to control all the entrances and exits of fabrics and other items, thus maintaining always updated the material stocks. The rack-to-rack location process was also applied to the accessories.

Fabrics are spread in flat tables and cut by a knife cutter. After cutting, the components are classified separately, bundled and separated the bundle with the instruction of documents, that include barcode, and continue forward to the sewing operations. This document use barcode to read production data and follow up to the finishing.

The process of sewing starts with the distribution of production batches by the machines compatible with the operations to be performed to finish the shirt. At each workstation, the operator has access to detailed information, step-by-step with a description of what to do as well as how to do it, and all information are showed for workers in the next step before they will do it. All this data is collected by barcode.

The program collects the quantity of products that each worker can produce in a day and provides it to the data having production monitoring on real time. The information flow system is created by using a JAVA application after they are collected by barcode. Before beginning any operation, the worker must identify the machine in which is working using the accurate function to show all information and to identify about status of every corresponding product.

At this stage, a barcode reader is attached to each machine. At the beginning of the task, the barcode entry to know exactly what to do and identifying the work. This period ends with the barcode scanner to complete the work. Then, the data is updated automatically into the system and managers can keep track of worker's productivity. The computer analysis done by the algorithm that has been installed, calculates several information for reporting and the degree of completion of work is displayed by different colors. At the end, workers are going to scan with a bar code reader for final product confirmation and the computer report the final output with the corresponding real-time.

3.3. *Postproduction processes*

Processes include thread trimming, pressing, inspection and quality control, folding, packaging and expedition. A barcode is randomly generated in the process of cutting and used for the finishing process. This code is also used in logistic and commercial.

3.4. *Bayesian process for GUIMA*

It is proposed to build a mathematical model supported by a Bayesian process and programed languages to GUIMA's production system achieve higher results (Figure 2). Bayesian process in production system is applied from preproduction processes to postproduction processes is having a purpose to estimate work efficiency as well as detecting for possible errors in each of the smallest and most specific details.

Moreover, this process also provides forecasts of product's productivity or any factor in system that can influence to production efficiency and is helping to have better decisions and controlling on time. Bayesian processed model integrated into one mechanism that is learned

from data of previous process will give out important experiences and data for next process - this is one of automated applications in machine learning and Artificial Intelligence fields.

Tools are intended to support this proposal that are programmed languages (Java, Pythons or Matlab) to simulate the Bayesian process.

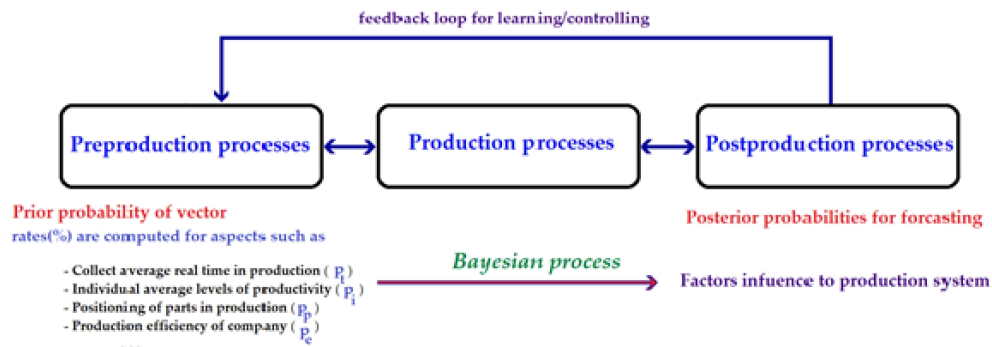


Figure 2. Bayesian process for production system

4. Conclusions

Throughout some evidences in the status of GUIMA that has already surveyed and characterized, shows how the digitalization is yet in a preliminary stage in the clothing industry. Some months ago, even the stocks of raw material were without a suitable organization to advance to digitalization.

The Industry 4.0 is a very important oriented approach for many fields and also for the competitiveness of the clothing industry in particular.

Industry 4.0 has two important components in manufacturing processes: the horizontal and vertical integration [15]. Horizontal integration is the connection between devices, workstations or separate plants, and it is also the cooperation between the different companies involved. Vertical integration in manufacturing is involving the actuators, sensors, controllers, production management, production and business planning starting from the suppliers until the customers. So, these two factors are necessary prepare the entire resources from the clothing companies (both human and technology) as well as organizing systems and processes to achieve this preliminary stage in GUIMA clothing company.

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